DESIGN A BATTERY CHARGER CONTOLLER FOR ELECTRIC VEHICLE
(MECHANICAL)

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A report submitted in fulfillment of the requirements
for the award of the Bachelor of
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"I hereby declare that I have read this project report and in my opinion this project report is sufficient terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering."

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I Mohd Hafizi bin Shaarani declare that this report entitled " *Design a Battery Charger Controller (Mechanical)* " is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....
Name : Mohd Hafizi b. Shaarani
Date : ....

I dedicated this meaningful project to my beloved mom..

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Throughout two semesters, I met numbers of lecturers and professionals who have assisted me in many ways towards completing my research. Firstly, I would like to express my sincere appreciation to my supervisor, Dr. Yusnita Rahayu, who generously shared his insights and suggestions, for his critics, trust, encouragement, and attention. Without their continued support and interest, this project report would not have been the same as presented here.

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ABSTRACT

This report is an outcome of the work I have carried out in doing and completing my final year project, Design a Battery Charger Controller for Electric Vehicle (Mechanical). The paper presents another design of battery charger controller that potentially can be apart of an EV system or somehow an explanation on the idea of basic battery charger controller in EV development process. It is an electronically project which required knowledge in electric and electronic field. The overall duty is to analyze the previous design of battery charger controller circuits and come out with a better design as suggestion of the battery charger controller which using microcontroller as the controller of the controller. The report starts with an introduction on EV, the advantages and disadvantages. Then a further introduction describe on the variety of battery type and their suitability to be used in the project. After gathering all the relevant information, the project undergoes design process. The knowledge gathered before is used to make a design which refers to problem statements that suitable for the project. There are comparisons and considerations are made in the designing stage based on self ability and condition. The project follows with writing the programming for the microcontroller using Visual Basic software in C language. The circuit then will be test as it will be the result for the ability of solving the problem statements of the project. At the end, when all the process mentioned above is done, the material for report writing is gathered. The report writing process will be guided by the University Malaysia Pahang final year report writing guide. This process also included the presentation slide making for the final presentation of the project. The project ended after the submission of the report and the presentation slide has been presented

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ABSTRAK

Laporan ini adalah hasil dari kajian saya dalam menyiapkan Projek Sarjana Muda saya bertajuk Rekaan Pengawal Pengecas Bateri untuk Kereta Elektrik (Mekanikal). Laporan ini membentangkan sebuah lagi rekaan pengawal pengecas bateri yang berpotensi menjadi sebahagian daripada sistem kereta elektrik masa hadapan atau paling tidak menjadi rujukan tentang idea asas sebuah pengawal pengecas bateri dalam proses menghasilkan sebuah kereta elektrik. Ia adalah sebuah projek elektonik yang memerlukan pemahaman dalam bidang elektrik dan elektronik. Keseluruhan tugas adalah untuk manganalisis rekaan litar pengawal pengecas bateri yang dihasilkan terdahulu dan memberikan cadangan lebih baik dalam merekabentuk sebuah pengawal pengecas bateri iaitu menggunakan microcontroller yang bertindak sebagai pengawal. Laporan ini dimulakan dengan pengenalan kepada kereta elektrik; kelebihan dan kelemahannya. Lanjutan pengenalan menyentuh kepelbagaian bateri yang digunakan dan kesesuaiannya untuk digunakan dalam projek ini.tentang kepentingan kekunci kereta dan kepentingannya kepada keselamatan kereta. Apabila semua maklumat berkaitan selesai dikumpulkan,projek ini akan diteruskan dengan fasa rekabentuk. Maklumat dan pengetahuan yang dikumpulkan digunakan untuk mengeluarkan sebuah rekaan berdasarkan kenyataan masalah yang sesuai dengan projek ini. Perbandingan dan pertimbangan telah dibuat dalam peringkat ini berdasarkan kemampuan dan keadaan sekeliling. Projek diteruskan dengan menulis kod program untuk microcontroller yang digunakan dengan menggunakan software Visual Basic dalam bahasa C. Rekaan litar akan diuji sebagai kayu ukur tentang kebolehannya menyelesaikan kenyataan masalah projek ini. Akhir sekali,laporan lengkap akan dirangka dan ditulis mengikut garis panduan yang ditetapkan oleh Universiti Malaysia Pahang.Selain laporan lengkap, slaid pembentangan juga akan disiapkan pada fasa teakhir projek ini.Projek ini berakhir dengan rasminya apabila ia berjaya dibentangkan dan laporan akhir dihantar.

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η	energy conversion efficiency
P_e	electrical input power
P_m	mechanical output power
V	input voltage
I	input current
T	output torque
ω	output angular frequency
W	Watt
kW	kilowatt
h	hour
A/Am	Ampere
mA	miliAmpere
^oC	degree celcius
MHz	MegaHertz

LIST OF ABBREVIATIONS

AC	Alternative Current
DC	Direct Current
V	Volt/Voltage
EV	Electric Vehicle
ICE	Internal Combustion Engine
RESS	Rechargeable Electric Storage System
FEV	Full Electric Vehicle
RPM	Revolution Per Minutes
PFC	Power Factor Correction
ESR	Equivalent Series Resistance
LCD	Light Crystal Display
LED	Light Emission Display

CHAPTER 1

INTRODUCTION

1.1 Introduction

An electric vehicle (EV) is a vehicle with one or more electric motors for propulsion. This is also referred to as an electric drive vehicle. The motion may be provided either by wheels or propellers driven by rotary motors, or in the case of tracked vehicles, by linear motors[18].

Unlike an internal combustion engine (ICE) that is tuned to specifically operate with a particular fuel such as gasoline or diesel, an electric drive vehicle needs electricity, which comes from sources such as batteries or a generator. This flexibility allows the drive train of the vehicle to remain the same, while the fuel source can be changed. The energy used to propel the vehicle may be obtained from several sources, some of them more ecological than others[21]:

- on-board rechargeable electricity storage system (RESS), called Full Electric Vehicles (FEV). Power storage methods include:
  - chemical energy stored on the vehicle in on-board batteries: Battery electric vehicle (BEV)
  - static energy stored on the vehicle in on-board electric double-layer capacitors

    - kinetic energy storage: flywheels
- direct connection to generation plants as is common among electric trains, trolley buses, and trolley trucks (See also : overhead lines, third rail and conduit current collection)
- renewable sources such as solar power: solar vehicle
- generated on-board using a diesel engine: diesel-electric locomotive
- generated on-board using a fuel cell: fuel cell vehicle
- generated on-board using nuclear energy: nuclear submarines and aircraft carriers

It is also possible to have hybrid electric vehicles that derive energy from multiple sources. Such as:[18]

- on-board RESS and a direct continuous connection to land-based generation plants for purposes of on-highway recharging with unrestricted highway range
- on-board rechargeable electricity storage system and a fueled propulsion power source (ICE): plug-in hybrid

Electric vehicles can include electric airplanes, electric boats, and electric motorcycles and scooters. The power of a vehicle electric motor, as in other vehicles, is measured in kilowatts (kW). 100 kW is roughly equivalent to 134 horsepower, although most electric motors deliver full torque over a wide Rotational Per Minutes (RPM) range, so the performance is not equivalent, and far exceeds a 134 horsepower fuel-powered motor, which has a limited torque curve. Usually, direct current (DC) electricity is fed into a DC/AC inverter where it is converted to alternating current (AC) electricity and this AC electricity is connected to a 3-phase AC motor. For electric trains, DC motors are often used[6][7].

To calculate a motor's efficiency, the mechanical output power is divided by the electrical input power:[3]

$$\eta = \frac{P_m}{P_e}$$

where η is energy conversion efficiency, P_e is electrical input power, and P_m is mechanical output power.

In simplest case,

$$P_e = VI, \text{ and } P_m = T\omega,$$

where V is input voltage, I is input current, T is output torque, and ω is output angular frequency.

1.2 Project Background

Oil, coal, and natural gas are collectively known as fossil fuels. We can simply say that all moving things on this earth are generate by fuel to move or function. But either we realize it or not, there are a number of problems associated with fossil fuels, most of which stem from the by-products created when they are burned to create energy. Chief among those byproducts are carbon dioxide and nitrous oxide, greenhouse gases that are major contributors to global warming. Largely because of coal and petroleum combustion, the amount of carbon dioxide and nitrous oxide in the air today are thirty-five percent and eighteen percent higher, respectively, than they were before the industrial era. Other byproducts of fossil fuel combustion include sulfur oxides and nitrogen oxides, both of which contribute to acid rain, and hydrocarbons, which can react with nitrogen oxides to form smog[1].

In addition to their environmental harm, the byproducts of burning fossil fuels can cause health problems for humans. Nitrogen oxides, for instance, irritate the lungs Particulate matter such as soot and dust contribute to respiratory illness and cardiac problems, including arrhythmias and heart attacks[2].

On the hands, the matters about fuel price which is cannot be maintained as it is base on the ups and downs of world economy start annoying the society. Remember the latest issue, the fuel price hike in late 2008 where there have been a lot of demonstrations of unsatisfied in number of countries. Fuel matters are actually the problem of the entire world and shocking that the world is actually facing the real big problem about fuel which is coming their way. There already have speculations that the world will be finished up the fossil from the some of the trusted source, thus, there would be no more fossil fuel can be produced. Even the car inventor does not know about this when they first invent a car. So it is actually nowadays problem and it is the responsibility of the people of this generation to find the suitable solution that can save them from this upcoming problem.

1.3 Objective

- To design a battery charger controller for an Electric Vehicles (EV).

1.4 Problem Statements

- Over charging the battery can cause damage either to the battery itself or even the other components that related.
- It is better to have a system which can automatically charge the battery when it has insufficient voltage.

1.5 Project Scope

- Limit to lithium ion battery (12V)
- Write a program for PIC 16F877A
- Voltage displayed on LCD
- Result showed by operating relay(s)

CHAPTER 2

ELECTRIC VEHICLE OVERVIEW

2.1 Advantages of electric vehicle

There are a lot of benefits that electric cars can bring us. This improves the goodness of having electric cars on the roads and highways. Some of the advantages are discussed here. The electric motors are known for its ability to release almost no air pollutants at the place where they are operated. Reducing the polluted air means there are clearer air which will be inhale by humans surround somehow reducing the health problem caused by the polluted air.

Second, the efficiency of electric motors is far away better than internal combustion engine. Electric motors often achieve 90% energy conversion efficiency over the full range of speeds and power output and can be precisely controlled[17]. They can also be combined with regenerative braking systems that have the ability to convert movement energy back into stored electricity. This can be used to reduce the wear on brake systems (and consequent brake pad dust) and reduce the total energy requirement of a trip, especially effective for start-and-stop city use. Plus, they can be finely controlled and provide high torque from rest, unlike internal combustion engines, and do not need multiple gears to match power curves. This removes the need for gearboxes and torque converters.

Another advantage is that electric vehicles typically have less vibration and noise pollution than a vehicle powered by an internal combustion engine, whether it is at rest or in motion[18]. Electricity is a form of energy that remains within the continent where it was produced and can be multi-sourced. As a result it gives the greatest degree of energy resilience.

Last but not least, the GM Volt, one of electric vehicle produced by Chevrolet, will cost less than purchasing a cup of coffee to recharge. The Volt should cost less than 2 cents per mile to drive on electricity, compared with 12 cents a mile on gasoline at a price of US dollar $3.60 a gallon. This would be the equaling to paying 70 cents a gallon of gas[20].

2.2 Disadvantages of electric vehicle

Electric Vehicles however still have the bad parts of it due to the electrical system they used. Many electric designs have limited range, due to the low energy density of batteries compared to the fuel of internal combustion engine vehicles. Besides, these batteries have long recharge times compared to the relatively fast process of refueling a tank.

A large number of electric cars would put significant strain on the grid if charged during peak use times, requiring additional investment in utility infrastructure. However, advocates have pointed out that the batteries of electric cars could be used to solve transmission problems if they are charged at off-peak times, by returning power to the grid at peak times. But this would reduce the daytime range of a parked electric car[14].

From a trusted resource give that overall average efficiency from United State power plants (33% efficient) to point of use (transmission loss 9.5%), (U.S. Department of Energy figures) is 29.87%. Accepting 90% efficiency for the electric vehicle gives us a figure of only 26.88% overall efficiency. That is lower than internal combustion engine vehicles (Petrol/Gasoline 30% efficient, Diesel engines 45% efficient - Volvo figures). Diesel engines can also easily run on renewable fuels, biodiesel, vegetable oil fuel (preferably from waste sources), with no loss of efficiency. Using grid electricity entirely negates the efficiency advantages of electric vehicles. This comparison does not take into account the lower practical efficiency of the internal combustion engine, due to transmission and idling losses. It compares tank-to-flywheel efficiency of gasoline and diesel powered engines to the well-to-wheel efficiency of electric motors[7].

To achieve a sound conclusion, one would also have to take into account the refining and delivery losses of gasoline and diesel, and the energy efficiency of biofuel production. (Output fuel energy divided by the sum of the invested energy and energy in the biomass). The equivalent for fossil electricity production would also need to be considered (mining and transportation of coal to the power station for example, or the carbon dioxide produced building renewable electricity generation).

Last but not least, in cold climates considerable energy is needed to heat the interior of the vehicle, and to defrost the windows. With ICE this heat can come for free from the waste heat from the engine cooling circuit. If this is done with battery power cars, this will require extra energy from the battery, although some could be harvested from the motor and battery itself. There would not be as much heat available as from an engine.

2.3 Issues with batteries

On an energy basis, the price of electricity to run an EV is a small fraction of the cost of liquid fuel needed to produce an equivalent amount of energy. Issues related to batteries, however, can add to the operating costs.

2.3.1 Lead-acid

Traditionally, most EVs have used lead-acid batteries due to their mature technology, high availability, and low cost (exception: some early EVs, such as the Detroit Electric, used nickel-iron.) Like all batteries, these has an environmental impact through their construction, use, disposal or recycling. On the upside, vehicle battery recycling rates top 95% in the United States. Deep-cycle lead batteries are expensive and have a shorter life than the vehicle itself, typically needing replacement every 3 years[31].

Lead-acid batteries in EV applications end up being a significant (25%-50%) portion of the final vehicle mass. Like all batteries, they have significantly lower energy density than petroleum fuels, in this case, 30-40Wh/kg. While the difference is not as extreme as it first appears due to the lighter drive-train in an EV, even the best batteries tend to lead to higher masses when applied to vehicles with a normal range. The efficiency and storage capacity of the current generation of common deep cycle lead acid batteries decreases with lower temperatures, and diverting power to run a heating coil reduces efficiency and range by up to 40%. Recent advances in battery efficiency, capacity, materials, safety, toxicity and durability are likely to allow these superior characteristics to be applied in car-sized EVs[32].

Charging and operation of batteries typically results in the emission of hydrogen, oxygen and sulfur, which are naturally occurring and normally harmless if properly vented. Early City car owners discovered that, if not vented properly, unpleasant sulfur smells would leak into the cabin immediately after charging. While for discharging, voltage depression or memory effect from repeated partial discharge can occur, but is reversible through charge cycling[32].

2.3.2 Nickel metal hydride

Nickel-metal hydride batteries are now considered a relatively mature technology. While less efficient in charging and discharging than even lead-acid, they boast an energy density of 30-80Wh/kg, far higher than lead-acid. When used properly, nickel-metal hydride batteries can have exceptionally long lives, as has been demonstrated in their use in hybrid cars and surviving NiMH RAV4EVs that still operate well after 100,000 miles (160,000 km) and over a decade of service[32].

Downsides include the poor efficiency, high self-discharge, very finicky charge cycles, and poor performance in cold weather. The NiMH battery has been produced which is used in the second generation EV-1, makes a nearly identical battery (ten 1.2V 85Ah NiMH cells in series in contrast with eleven cells for Ovonic battery). This worked very well in the Saturn EV-1. It remains a viable and practical solution today, as far as a superior alternative to the lead acid battery. However, for non-technical reasons neither company will provide their NiMH battery for automotive applications - a policy strictly enforced. Moreover, GM now owns patent(s) on some proprietary technology and processes used to manufacture this type of battery. Therefore no other company can produce a similar battery (with capacities large enough for electric vehicle propulsion) without infringing GM's patents. So, despite its technical success, unless GM will change their position on the issue NiMH traction battery technology, it is considered a dead end. In light of the latest developments in lithium based battery technology and patent issues of NiMH, lithium will most likely represent the future EV battery type[31].

2.3.3 Zebra

The sodium or "zebra" battery uses a molten chloroaluminate (NaAlCl4) salt as the electrolyte. Also a relatively mature technology, the Zebra battery boasts a good energy density of 120Wh/kg and reasonable series resistance. Since the battery must be heated for use, cold weather doesn't strongly affect its operation except for in increasing heating costs. It has been used in several EVs. The downsides to the Zebra battery include poor power density (<300 W/kg) and the requirement of having to heat the electrolyte to 270 ^{o}C, which wastes some energy and presents difficulties in long-term storage of charge. Zebras can last for a few thousand charge cycles and are nontoxic [32].

2.3.4 Lithium Ion

Lithium-ion (and similar lithium polymer) batteries, widely known through their use in laptops and consumer electronics, dominate the most recent group of EVs in development. The traditional lithium-ion chemistry involves a lithium cobalt oxide cathode and a graphite anode. This yields cells with an impressive 160Wh/kg energy density and good power density, and near lossless charge/discharge cycles. The downsides of traditional lithium-ion batteries include short cycle life (hundreds to a few thousand charge cycles) and significant degradation with age. The cathode is also somewhat toxic. Also, traditional lithium-ion batteries can pose a fire safety risk if punctured or charged improperly. The maturity of this technology is moderate. The Tesla Roadster uses "blades" of traditional lithium-ion "laptop battery" cells that can be replaced individually as needed.

Most other EVs are utilizing new variations on lithium-ion chemistry that sacrifice energy density (often resulting in batteries with 100Wh/kg or less) to provide extreme power density, fire resistance, environmental friendliness, very rapid charges (as low as a few minutes), and very long lifespan. These variants (phosphates, titanates, spinels, etc) have been shown to have a much longer lifetime, with A123 expecting their lithium iron phosphate batteries to last for at least 10+ years and 7000+ charge cycles[8], and LG Chem expecting their lithium-manganese spinel batteries to last up to 40 years.

Much work is being done on lithium ion batteries in the lab. Lithium vanadium oxide has already made its way into the Subaru prototype G4e, doubling energy density.